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THE EFFECT OF AGE AT FIRST ESTRUS (PUBERTY) ON MATURE BODY SIZE AND LONG-TERM REPRODUCTIVE PERFORMANCE OF SOWS

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FINAL REPORT

"The Effect of Age at First Estrus (Puberty) on Mature Body Size and Long-term Reproductive Performance of Sows."

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EXUCTIVE SUMMARY

Results of the study indicate that:

1. If early pubertal stimulation is used as a "selection" technique, 125% of breeding gilt requirements should enter the stimulation phase (expecting 25% not to cycle or to be culled) to obtain the required number of gilts cycling within 40d of boar exposure.

2. With growth rates exceeding 0.7kg/d from birth to puberty, gilts would need to cycle by 171 days (31 days after start of stimulation at 140d) to be "selected" below market weight. 37% of all gilts failed to achieve this, and could potentially represent a financial penalty to the breeding unit.

3. Large variation in weights and ages at puberty were observed, ranging from 75.8 - 151.4 kg and 132 - 190 d, respectively. Management strategies must be developed to minimise the effect of this variability on lifetime performance.

4. Important differences in production efficiency related to selection on age at first estrus exist. Considered together with increased costs of higher replacement rates, costs of time spent on unproductive heat checks and increased breeding costs per pig born, our data suggest substantial savings can be realized by identifying late-cyclic and non-cyclic gilts at an early age.

5. Gilt selection based on recorded first estrus during periods of good boar contact (heat-no-serve) is therefore predictive of lifetime reproductive performance and should become a standardized procedure in breeding herd management.

TECHNICAL REPORT

Background

1. **Reduction in non-productive days:** Replacement gilts reared under commercial conditions and fed to appetite are quite capable of reaching market weight (110 - 115 kg) around 160 days of age. However, for various reasons, Canadian producers delay inducing gilts into first estrus (puberty) until 180 to 240 days of age. This strategy usually increases the herd's non-productive days. Recent intensive studies at the University of Alberta have suggested that the onset of puberty is actually delayed in the fastest growing gilts, resulting in weight at puberty increasing by as much as 35 kg due to effects of fast growth and delayed stimulation. We need to more clearly characterize the relationship between prepubertal growth rate, age at puberty and response to boar stimulation in order to issue practical recommendations as to how to manage gilts to minimize non-productive days as gilts enter the breeding herd.
2. **Larger mature body size:** Modern gilts grow faster, are leaner and heavier at puberty than gilts a decade ago. Producers argue that a reason for delaying boar stimulation is that gilts require additional weight and(or) fat to prevent the "second parity dip", a reduction in litter size observed at second parity in primiparous sows that deplete too much tissue to sustain the demand of the nursing piglets during their first lactation. However, heavier weights at puberty result in a larger body size and an additional nutrient demand for maintenance. This demand is likely to increase lifetime feed cost, and cause welfare concerns because of increased physical size of modern sows. We need to more clearly characterize the relation between body size at puberty and lifetime changes in size and condition. This will establish what is the optimum weight and(or) tissue mass at puberty that is consistent with high lifetime productivity but minimal maintenance requirements and reduced culling on welfare grounds.
3. **Sexual precocity may relate to fertility:** Ongoing research at the University of Alberta provide evidence for the physiological link between sexual maturity and other measures of fertility in the gilt and sow. Therefore, we hypothesized that prepubertal gilts that first respond to stimulation with boars are also likely to be the sows that have better lifetime fertility (larger litters, prompt returns to estrus after weaning) whilst late responders have poor lifetime performance (irregular litter size, delayed return to estrus, inconsistent signs of heat or short estrus duration, higher return rates). To encourage producers to adopt more efficient management strategies for replacement gilts, we need to provide clear evidence for a relationship between sexual precocity and lifetime fertility. Because delayed puberty demands proportionally more labour and economic input to introduce and retain gilts in the breeding herd, and contributes disproportionately to herd non-productive days, we need to find improved management strategies to alleviate these problems.

Project Objectives

508 replacement gilts (C_{22s} and L_{42}) were used:

1. To characterize the relationship between prepubertal growth rate, age at puberty and response to boar stimulation in order to issue practical recommendations as to how to manage gilts to minimize non-productive days as gilts enter the breeding herd.

2. To characterize the relationship between body size at puberty and lifetime changes in size and condition in order to establish the optimum weight and(or) tissue mass at puberty consistent with high lifetime productivity but minimal maintenance requirements and reduced culling on welfare grounds.

3. To characterize the relationship between sexual precocity and lifetime fertility in order to issue practical recommendations for efficient management strategies for replacement gilts.

Methodology

Animals

This study was completed at Prairie Swine Centre, Floral (PSCF) and Prairie Swine Centre, Elstow (PSCE) production facilities and was approved by the University Committee on Animal Care and Supply (UCACS), University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Research work involving these animals commenced in August 2001. Five hundred and eight prepubertal gilts (PIC, Canada), consisting of L42 (C3 female X L2 male) (n = 425) and C22 (L42 female X L19 male) (n = 83) gilts, born to multiparous sows were used in this study. Gilts were on the study starting from approximately 100 days of age through to d30 of gestation in parity 4. Gilts were culled as necessary and as per typical commercial practices, for failure to exhibit a pubertal estrus and be bred, failure to conceive, abortion, low productivity, failure to return to estrus within 18 days after weaning, locomotion problems, emaciation, and death.

Gilt development

Barn 7 at PSC Floral served as the gilt development barn that supplied the gilts to maintain the gilt pool at both PSCF and PSCE. Gilts were housed in pen groups of twenty, on partially slatted floors, with artificial light from 0700 until 2100 and were permitted at least 0.7 m^2 space allowance throughout the gilt development and puberty stimulation phases. All gilts were allowed *ad libitum* access to water and to diets from one four-holed feeder per pen (Table 1). Temperature was monitored and recorded daily using a min/max thermometer. Gilts were allocated to trial at a pen average of 100 days of age. Gilt weight, loin depth and backfat depth were determined approximately at 100 days of age.

Puberty Stimulation

Starting at approximately 140 days of age, groups of gilts were taken daily to a boar stimulation area, and received approximately 20 minutes direct contact to a boar and fenceline exposure to three other boars housed in the same area (Figure 1). Four mature epididimectomized boars were used in rotation and a gilt:boar ratio of no greater than 10:1 was used. Physical signs of pending estrus, such as redness, degree of swelling, and mucosal discharge from the vulva were recorded daily during the stimulation period. Puberty attainment was determined as the day gilts first exhibited the standing reflex in response to exposure to a boar. Boars were not permitted to breed the gilts, but were "hand collected" on a regular basis to maintain their libido.

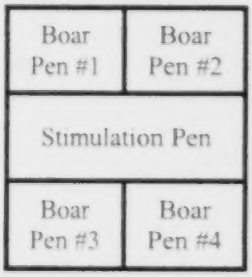


Figure 1. Diagram of the puberty stimulation area in Barn 7 at PSCF.

Gilts not exhibiting the standing reflex (non-cyclic) by a pen average of 180 days, were considered Non-Responsive. Non-Responsive gilts were removed from the intensive portion of the study at approximately 180 days of age but available to the breeding barn to manage as they saw fit to meet breeding targets.

Breeding and Management

On the day that a gilt reached puberty during the 140-180 day stimulation period she was removed from her pen and relocated to a pen designated for cyclic gilts. Gilts were allowed *ab libitum* access to the gilt finisher diet and water. On day 18 of the first estrous cycle, gilts were permitted daily fenceline contact with four mature boars for detection of 2nd estrus. After 2nd estrus was detected gilts were relocated to the breeding barns at two sites, Floral or Elstow, within 7 days of the onset of 2nd estrus. At Floral, gilts were housed in one of three barns in groups of 4 to 6; at Elstow gilts were either housed in small groups of 4 or in the electronic sow feeding (ESF) system in large pen groups. At approximately d 18 of the 2nd estrus cycle, gilts were again permitted fenceline contact with mature boars for detection of 3rd estrus. At the detection of standing heat and every 24 hours for the duration of standing heat, gilts were inseminated using pooled semen at a dose of 3.0 X 10^9 morphologically normal sperm (PIC, Canada) per insemination. Semen was no older than 3 days from the collection date. Gilts and sows were allowed fenceline contact with mature boars during insemination.

After breeding, gilts at both facilities were housed in single gestation stalls, small or large group (ESF) housing. All gilts were managed similarly. Females housed in small group pens were fed the gestation diet once per day. Gilts housed in gestation stalls or ESF were fed according to body condition.

At approximately day 110 of gestation, sows were moved from the gestation room to the farrowing room crates. Sows were offered the standard lactation diet at approximately 3.0 and 3.2kg/day for 1st- and 2nd-parity sows, respectively, split into three meals of approximately the same size offered at approximately 08:00, 11:30 and 15:30h until the day of parturition. Sows were induced to farrow using $PGF_{2\alpha}$ on Day 113. Sows were fed at the discretion of the farrowing room personnel on the day of parturition. The piglets were normally processed (ear notching, tail docking and iron injection) within 24h of birth. Litter size was standardized, as much as possible, to 10-11 piglets across all sows farrowing in each barn within 48h. Only under special circumstances did cross-fostering occur after 48h. At farrowing, total piglets born alive, stillborn and mummified were recorded. Sow weight, loin depth and backfat depth were measured within 7 days of parturtion. Lactation length varied between 13 – 34 days. At weaning, all remaining suckling piglets were removed, and the sows were relocated to either gestation stalls or small pen group housing. Sow weight, loin depth and fat depth were determined within 7 days of weaning. Sows were permitted fenceline contact with a mature boar daily from day 3 after weaning for detection of estrus. Weaning-to-estrus (WEI) was recorded and any gilt failing to return to estrus within 18 days was culled. At the detection of standing heat and every 24 hours for the duration of standing heat, gilts were inseminated using pooled PIC semen at a dose of 3.0 X 10^9 morphologically normal sperm (PIC, Canada) per insemination. Parities 2 and 3 sows were treated similarly. The reason for any pig being removed from the experiment, or culled from the herd prior to achieving their 3rd parity was recorded.

Gilt performance data (total born alive, stillborns, farrow/wean dates, etc.) were monitored using PigCHAMP (Ames, Iowa, USA).

Ultrasound and weight measurements

During the study, gilts and sows were weighed, and backfat depth and loin depth were determined ultrasonically (Pie Medical Scanner 200, Classic Medical Inc., Tequesta, Florida, USA), at several time points. Weights, loin depth, and backfat depth were recorded at approximately 100 days of age, at puberty or 180 d of age, 1st breeding and at farrowing and weaning for three consecutive parities. A single longitudinal scan using a 3.5 MHz linear probe was obtained by placing the transducer probe parallel to the midline of the gilt approximately 5 cm from the midline. The scan was measured from the last rib until approximately the 3 or 4th last rib. At the time of ultrasonography, the scan was visually appraised and loin and backfat depth measured. Scans were completed by experienced technicians.

Gilt and Sow Feeding

Gilts and sows were fed commercial diets that were least-cost formulated, thus the ingredient composition of the diets varied but the nutrient composition of the diet remained constant (Table 1).

Table 1. Calculated nutrient composition of diets

	Gilt Finisher	Gestation	Lactation
Nutrient Composition			
DE (Mcal/kg)	3.30	3.00	3.38
Crude Protein (%)	23.8	15.4	21.0
Lysine, gDlys/Mcal DE	2.00	1.46	2.45
Calcium (%)	0.70	0.85	0.81
Phosphorus, total (%)	0.60	0.75	0.65

Blood sample collection

To determine metabolic status, at d100, puberty, breeding, farrowing and weaning for 3 consecutive parities, two 5 mL jugular blood samples were taken between 0900 and 1400 h from all available gilts during a brief period of nose-snare restraint. All samples were centrifuged at 1,000 x g for 15 min and plasma decanted and stored at approximately –20°C until analysis for leptin and IGF-1 concentration.

To ensure that Non-Responsive gilts were truly non-cyclic, at approximately 170 and 180 d of age, a single jugular blood sample was taken during a brief period of nose-snare restraint, for analysis of progestagen concentration to determine reproductive activity. Gilts were considered previously cyclic if plamsa progesterone concentrations were high (>1 ng), and data from these gilts were excluded from the statistical analysis.

Project Deviations

Deviations from the initial work plan were as follows:

1. The first deviation was an extension of the initial time line due to 1) a delay in the start of the project, and 2) an overestimation of gilts available on a monthly basis. Initially the project was to begin in May 2001 but the actual start date was August 15, 2001. Secondly, the predicted target of 42 C22 gilts would be available per month were not available on a consistent basis,

and actual availability of gilts per month ranged from 10 to 131. Also, to increase gilts numbers, we decided to use L42 gilts in addition to C22 gilts.

As predicted in the April 2003 Interim Report, the animal work was completed by March 2004. As shown in Table 2, complete data sets are available for 388 gilts that have either reached parity 3 or greater, or been culled.

Table 2. Fate of gilts starting trial

	Distribution	Total
Fate of gilts starting trial:		
Puberty Attained	379	
Non-Responsive	112	
Lame	12	
Tailbite	3	
Other	2	
		491
Bred	**442**	
Missing	49	
		491
Farrow 1	392	
Farrow 2	324	
Farrow 3	252	

2. The period during which gilts are exposed to the epididimectomized boar was extended, from 170 to 180 days of age. The extension was necessary to obtain pubertal data on the largest number of gilts possible.

3. The slaughter of non-responders and collection of their reproductive tracts. Due to the logistics and excessive cost of slaughter and reproductive tract collection, we opted to take two carefully planned blood samples as a technique to monitor corpus luteum function, to ensure that the first observed and recorded estrus was truly the pubertal estrus.

Results & Conclusions

Puberty Stimulation

Five-hundred and eight L42 and C22 (PIC Canada, Inc.) prepubertal gilts began the trial at approximately 101.5 days of age and 61.0 kg body weight. Table 2 shows the fate of gilts that originally began trial at 140 days of age until the end of the puberty stimulation period (approximately 180 days of age). Seventeen gilts were removed from the trial before they reached 180 days of age due to lameness, tailbites, etc. Overall, out of 508 gilts, 75% of gilts were pubertal within 40 days of stimulation (Responsive; R) and 22% of gilts were considered non-pubertal (Non-Responsive; NR). Figure 2 illustrates the overall distribution of the age of the gilts that reached puberty. Based on the results, we conclude that if early pubertal stimulation is used as a "selection" technique, approximately 125% of breeding gilt requirements should enter the stimulation phase (expecting 22% not to cycle and 3% to be culled) to obtain the required number of "selected" gilts to have a recorded first estrus within 40d.

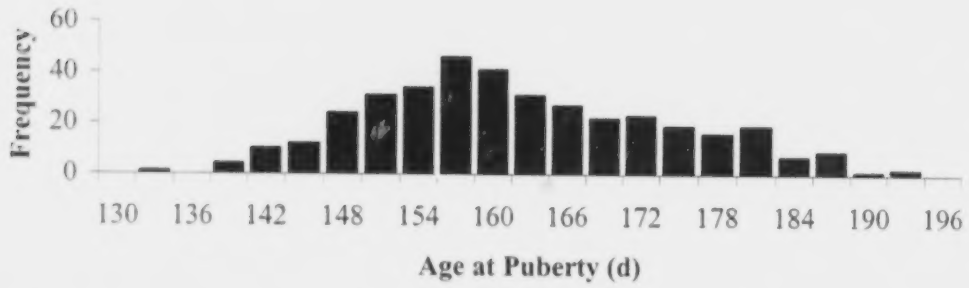


Figure 2. Overall distribution of age at which gilts reached puberty (n=379).

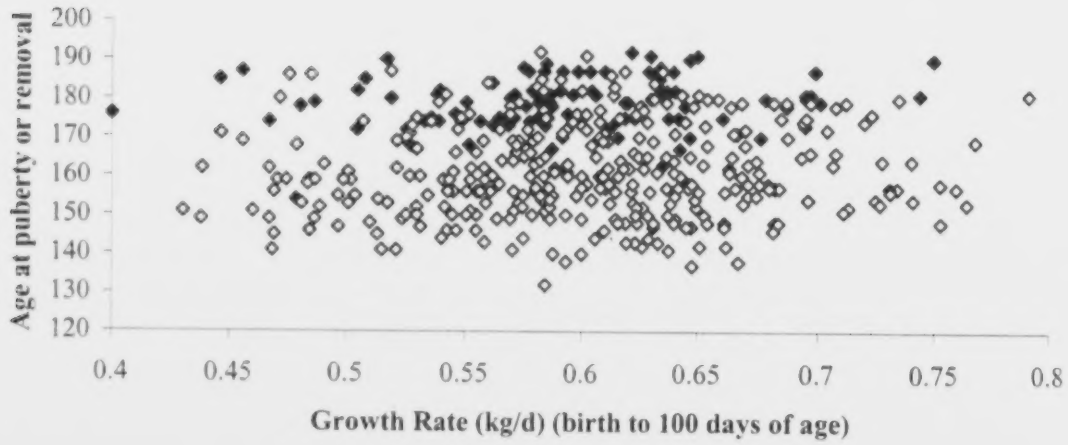


Figure 3. Relationship between growth rate from birth to 100 d of age and age at puberty or removal from the study. Closed diamonds represent Non-Responsive gilts removed at approximately 180 days; open diamonds represent gilts that reached puberty within the 40-day period of boar stimulation.

Our results confirm that at commercially acceptable growth rates (0.55 – 0.80 kg/d) there is no relationship between growth rate (birth to 100 days of age) and age at puberty (Figure 3). As a consequence, inherent differences in age at puberty (Early, Intermediate, Late, Non-responders) affected weight, backfat depth and growth rate at puberty (Table 3). The largest proportion of gilts (31.7%) were classified as Intermediate (first estrus between 154 and 167 days of age) followed by Late (22.4%; first estrus between 168 and 180 days of age), Non-Responders (22.0%; did not exhibit first estrus by 180 days of age) and (Early 20.5%; first estrus between 140 and 153 days of age). As expected, age at puberty and days to puberty (measured as the number of days from initial exposure to the boar until the gilt exhibited the standing reflex) were significantly different between groups ($P < 0.05$). Gilts that were classified as Late or Non-Responders were heavier than Early or Intermediate gilts ($P < 0.05$). Backfat depth did not differ between any of the classification groups ($P > 0.05$). A significant difference in lifetime growth rate measured from birth to puberty or 180 days of age was detected; Intermediate, Late and Non-Responsive gilts had similar growth rates and grew faster than Early responding gilts ($P < 0.05$).

Table 3. Characteristics measured at the onset of puberty (1st estrus) and at breeding

	Early	Intermediate	Late	Non-Responders†	SEM	Group *P*-Value‡
#, gilts	104	161	114	112	-	-
Pubertal Age (d)*	148.5[a]	159.7[b]	175.3[c]	*(>180)*	0.81	0.0001
Days to Puberty (d)	8.5[a]	19.6[b]	35.2[c]	*(>40)*	0.82	0.0001
Weight (kg)	106.1[a]	118.0[b]	128.3[c]	131.3[c]	2.0	0.0001
Backfat depth (mm)	12.7	13.7	13.7	13.5	0.45	0.2366
Growth Rate (kg/d)	0.688[a]	0.718[b]	0.722[b]	0.729[b]	0.009	0.0014
Breed Weight (kg)	133.0[a]	145.0[b]	154.7[c]	-	1.8	0.0001
Breed Backfat (mm)	14.1	15.5	14.4	-	0.5	0.0594
Breed Loin (mm)	56.7	57.8	58.3	-	0.8	0.3854

† Average age of non-responders was 179.7 days at the time of removal from the experiment.
* Puberty is defined as the first day a gilt exhibits the standing reflex in the presence of a boar.
‡Group defined as the difference between early, intermediate, late and non-responders.

An important point that producers should consider is the weight of the gilts considered non-responders at 180 days of age. Overall, 23% of all gilts were considered non pubertal and nearly 80% of these were above market weight (120 kg), thus resulting in a financial penalty to the producer if these gilts were to be removed as market animals (Figure 4). Therefore, we stress here the importance of identifying non-responsive gilts at a younger age and lighter weight. This can be achieved through well managed gilt pool management techniques (i.e. boar stimulation starting at 160 d of age, daily supervised direct exposure to mature boars, and culling of non-responders by 30d).

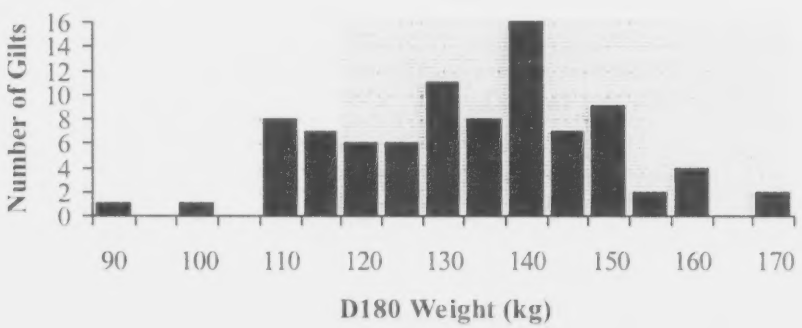


Figure 4. The weight of non-responders at 180d of age

Breeding

In this study, ages and weights at puberty ranged from 132 to 190 d and 75.8 to 151.4 kg, respectively. The large range in weight at puberty was reflected in variation in weight at breeding (Figure 5), with breeding designated to occur at 3rd estrus, which presents several problems to the producer. Gilts that are heavyweight at breeding increase feed, barn space and labour costs and may cause welfare concerns because of the larger physical size of mature sows. Conversely, gilts that are lightweight at breeding may lack the necessary body reserves required to sustain body condition through several parities. Therefore, management strategies must be developed to minimize the impact of this variability on lifetime reproductive performance, and retention in the herd.

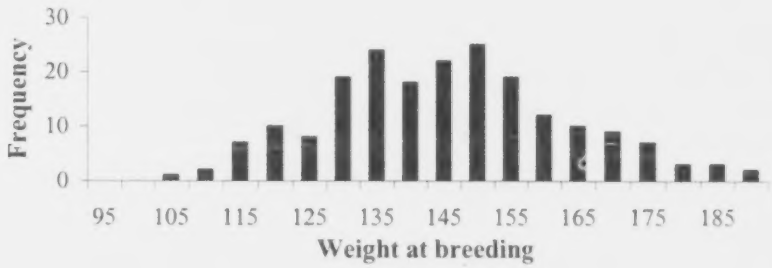


Figure 5. Overall distribution of weights at breeding

Calculated estimates of cumulative non-productive days (NPD) per gilt originally on inventory, inclusive of NPD due to gilts and sows culled by d 18 after weaning, were EP, 50.5; IP, 58.5; LP, 75.5 and NP, 71.1 d (Table 4). The calculated NPD per pig born in the first litter were EP, 5.9; IP, 6.8; LP, 8.9 and NP, 11.2 d. These data indicate important differences in production efficiency related to selection on age at first estrus.

Table 4. Breeding herd efficiency as determined by NPD accumulated by d30 of gestation of parity 2. (Prairie Swine Centre, and University of Alberta, Swine Research and Technology Centre, unpublished data 2003)

	EP	IP	LP	NR	SEM	*P*-Value
NPD actual [1,2]	50.5[a]	58.5[ac]	75.5[b]	71.1[bc]	4.6	0.0002
NPD predicted[3]	*41.2*[a]	*41.4*[a]	*49.2*[a]	*69.2*[b]	*4.7*	*0.0001*
Born Alive	10.1	10.1	10.3	10.2	0.3	0.3583
Born Alive Adjusted[4]	8.5	8.6	8.5	6.2	-	-
NPD/pig born[5]	5.9	6.8	8.9	11.4	-	-
NPD/pig born[6]	*4.8*	*4.8*	*4.8*	*11.2*	-	-

[1]NPD calculated from 170d (days to reach slaughter weight of 120 kg with an average growth rate of 0.71 kg/d)

[2]Actual # NPD accumulated to d30 of gestation of parity 2

[3] *Predicted # NPD if gilts bred at 135 kg body weight or 3rd estrus*

[4] (Total # gilts available X farrowing rate X actual born alive)/total number of gilts available

[5] NPD actual/born alive adjusted

[6] *NPD predicted/born alive adjusted*

Based on these results to overcome the problems associated with large variations in weight at breeding (Figure 5) and to reduce the accumulation of NPD, a stricter selection program should be implemented. Available evidence suggests that a sow body weight ≥180 kg at farrowing is protective against the negative effects of weight loss normally observed in first lactation. Therefore, assuming a gestation weight gain of 40 kg, at breeding ***gilts should weigh between 135 – 150 kg at breeding.*** However, recorded growth rates of the gilts studied suggests that gilts with lower growth rates would require excessive NPD to reach 135 kg at breeding. We therefore, suggest that all gilts should be bred no later than ***third estrus***. If the gilts in the present study had been bred within a 135-150 kg weight range, with an upper limit of 3rd estrus for breeding, the number of non-productive days would be dramatically reduced (*NPD predicted* in Table 4).

Productivity & Retention Rate

Figure 6 illustrates the percentage of gilts that reached specific milestones out of the total number of gilts initially on inventory in each response category. Analyzed on the basis of overall performance of gilts originally on inventory, R (gilt recorded as initially responding to boar contact) showed greater long-term productivity than NR gilts ($P<0.01$), as measured by the percentage of gilts successfully bred (R = 96.2 vs. NR = 75.2 %), and farrowing one (R = 85.0 vs. NR = 64.2 %), two (R = 72.2 vs. NR = 49.5 %), or three litters (R = 57.6 vs. NR = 37.0 %). A difference in the average litters produced per gilt on inventory (R = 2.5 ± 0.1 vs. NR = 1.7 ± 0.1 litters), reflected a lower retention rate of NR gilts in the breeding herd.

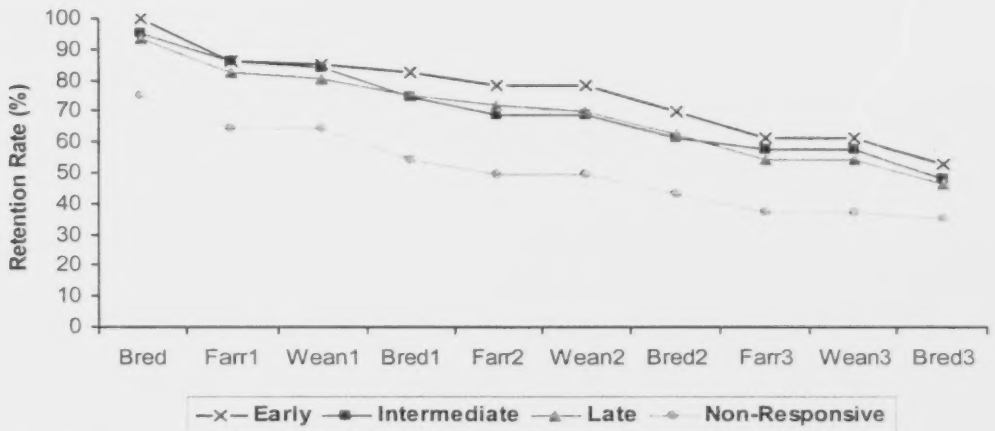


Figure 6. Retention Rate for Early, Intermediate, Late and Non-Responsive gilts.

Culling Rate

There were no overall differences between groups in the reason for removal from the herd (culling) Overall, 10, 11, 17 and 22% of females were removed before first breeding as gilts, parity 1 farrow, parity 2 farrow and parity 3 farrow, respectively. Over three parities a total of 245 gilts have been culled from the herd. Of culled gilts the majority of gilts (59 %) were removed because of reproductive failure (no heat, abortion, not pregnant, poor fertility, did not conceive, etc.).

Litter Size

Total born alive, born dead and mummies for Early, Intermediate, Late and Non-Responsive gilts are shown in Table 6. Considering only females that farrowed, there were no significant differences in born alive between groups ($P > 0.10$). The only detected difference was in total number of pigs born dead in parity one, Late pubertal females. These data suggest that once gilts have been bred, there are no differences in litter size.

Table 5. Reason for removal for Early, Intermediate, Late and Non-Responsive gilts over three parities

	Early (%)	Intermediate (%)	Late (%)	Non-Responsive (%)	Grand Total (%)
Body Condition	0	1.4	0	2.7	**1.0**
Death	10.4	9.8	2.1	10.8	**8.4**
Lameness	10.4	7.0	8.5	10.8	**8.9**
Productivity	10.4	7.0	19.1	5.4	**12.8**
Reproductive	58.3	60.6	57.4	62.2	**59.6**
Other	10.4	7.0	12.8	8.1	**9.4**

Table 6. Litter data in parities 1, 2 and 3 for Early, Intermediate, Late and Non-Responsive gilts

		Early	Intermediate	Late	Non-Responsive
Parity 1	Total Born Alive	10.2 ±0.3	10.0 ± 0.2	10.3 ± 0.3	10.2 ± 0.3
	Total Born Dead	0.5 ± 0.1	0.7 ± 0.1	1.0 ± 0.1	0.5 ± 0.1
Parity 2	Total Born Alive	10.5 ± 0.3	10.4 ± 0.3	10.4 ± 0.3	10.4 ± 0.4
	Total Born Dead	0.6 ± 0.1	0.7 ± 0.1	0.8 ± 0.1	0.6 ± 0.2
Parity 3	Total Born Alive	11.6 ± 0.4	10.3 ± 0.3	11.2 ± 0.4	11.3 ± 0.5
	Total Born Dead	0.7 ± 0.2	1.0 ± 0.1	0.8 ± 0.1	0.9 ± 0.2

Total Born Alive -- *P*-Value: Group = 0.7521; Parity = 0.0001; Group*Parity = 0.6161

Total Born Dead-- *P*-Value: Group = 0.0748; Parity = 0.3897; Group*Parity = 0.4454

Sow Body Condition

Table 7 illustrates the differences in body weight and backfat depth measured at 1st breeding, farrowing and weaning over 3 parities. Initial differences in weight at puberty and at breeding (Table 3) resulted in significant differences in 1st and 2nd parity farrow weight and 1st parity weaning weight ($P < 0.05$). There were no differences in backfat depth ($P > 0.05$).

Progesterone Analysis

Samples taken from 223 d170 and d180 gilts considered non-pubertal, were analysed for progesterone concentration. Five gilts had progesterone concentrations that may indicate a silent or undetected heat. After progesterone analysis was complete, the results were compared to heat-check records. Pig 66304L likely stood, and had a missed heat. Gilts 08703L, 13102K, and 41103K did not show any

signs of heat (redness, degree of swelling, and mucosal discharge from the vulva). However, gilt 02306L did not stand within 180 days of age, she was showing signs soon after, which resulted in an increased progesterone concentration.

Future Development

A final paper will be compiled for submission to Journal of Animal Science by late summer 2004. We will forward a copy of the final paper to ADF and SaskPork when it is completed.

Taking the results from this study into consideration we have prepared and submitted and received funding for a follow-up study that we feel will further benefit producers, entitiled **"The impact of first breeding weight irrespective of age on long-term reproductive performance of sows"**. The results of this new study will compliment the current study and will allow us to further refine gilt pool management, taking account the huge variation in weight at breeding observed in the present study. We hope to be able to recommend to producers how to best manage the gilt pool to reduce variability in weight at breeding and thus further minimize lifetime NPD in the breeding herd. Collectively the results will increase overall sow lifetime performance and breeding herd productivity and decrease labour requirements in the gilt development barn.

Table 7. Body weight and backfat depth in parities 1, 2 and 3 for Early, Intermediate, Late gilts

		Early	Intermediate	Late
Parity 1	Farrow Weight	179.8 ± 1.8^{a}	189.6 ± 1.6^{b}	198.8 ± 1.8^{c}
	Farrow Backfat	14.6 ± 0.4	15.0 ± 0.4	15.2 ± 0.2
	Wean Weight	171.9 ± 2.1^{a}	178.6 ± 1.6^{a}	188.5 ± 2.0^{b}
	Wean Backfat	12.7 ± 0.5	12.9 ± 0.4	13.4 ± 0.5
Parity 2	Farrow Weight	217.2 ± 2.0^{a}	223.1 ± 1.8^{a}	229.1 ± 2.1^{b}
	Farrow Backfat	14.9 ± 0.6	15.6 ± 0.5	14.2 ± 0.5
	Wean Weight	211.1 ± 2.2	213.7 ± 2.0	214.6 ± 2.5
	Wean Backfat	14.4 ± 0.6	13.7 ± 0.5	14.5 ± 0.6
Parity 3	Farrow Weight	250.4 ± 2.5	250.8 ± 2.1	259.7 ± 2.5
	Farrow Backfat	16.2 ± 0.6	15.0 ± 0.5	15.5 ± 0.6
	Wean Weight	239.5 ± 2.9	241.8 ± 2.5	247.0 ± 3.0
	Wean Backfat	15.3 ± 0.7	14.6 ± 0.5	14.4 ± 0.7

Differences in subscripts within rows represent differences ($P < 0.05$)

Personnel

Jennifer Patterson was the project co-ordinator responsible for the project.

Crissandra Auckland was the primary technician responsible for the project at PSCF and PSCE.

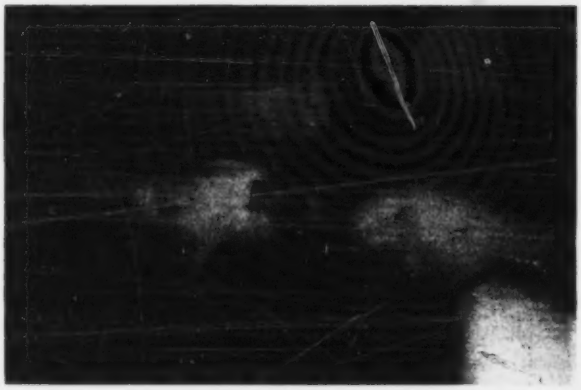
Deneille Tocher was an assisting technician for the project.

Tamara Leader was a casual technician for the project.

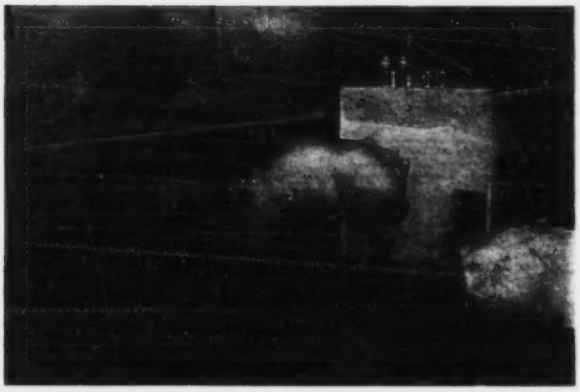
Equipment

None have been purchased at this time.

Project Photos

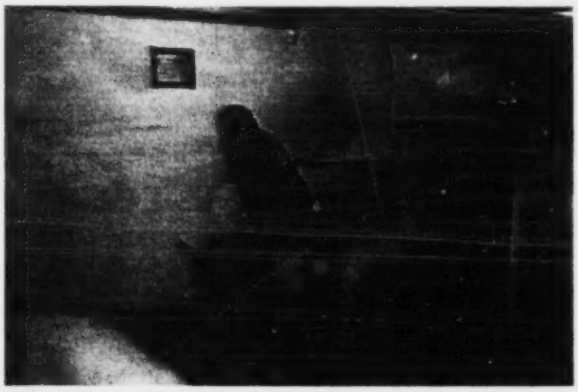


Stimulation Area PSCF Barn 7 – Boar & Gilts.

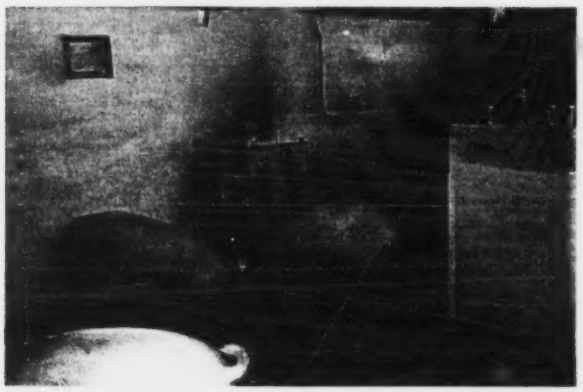


Stimulation Area PSCF Barn 7 – Boar & Gilts.

Stimulation Area PSCF Barn 7 – Technician recording signs of pending estrus



Stimulation Area PSCF Barn 7 – Technician performing back pressure test.



Stimulation Area PSCF Barn 7 – Technician performing back pressure test.

PSCF Gestation Barn – Technician scanning for backfat and loin depth.

Publications and presentations arising from this project

Conference Proceedings

- Foxcroft, George, Jennifer Patterson, Eduardo Beltranena, and Murray Pettitt. 2004. Identifying the true value of effective replacement gilt. Proceedings Manitoba Swine Seminar. Winnipeg, MN, 35 pp.
- Patterson, Jennifer, George Foxcroft, Eduardo Beltranena, and Murray Pettitt. 2003. Gilt Pool Management for Improved Production. 5th Annual Red Deer Swine Technology Workshop. Red Deer, AB, p1.
- Foxcroft, G. R. 2002. Fine Tuning the Breeding Program. Saskatchewan Pork Industry Symposium 2002 Conference Proceedings, p49
- Foxcroft, G.R., J. Patterson, H. Willis, and F. Aherne. 2002. Managing the gilt for maximum lifetime production. American Society of Animal Science Midwestern Section, Des Moines, IA, p48

Abstracts

- Patterson, J.L., G.R. Foxcroft, M. Pettitt and E. Beltranena. 2004. Gilt selection for improved lifetime productivity. *To be presented at Federation of Animal Science Socities (FASS) Meeting in St. Louis, Missouri July 2004* (Appendix G)
- Patterson, J.L., G.R. Foxcroft, M. Pettitt and E. Beltranena. 2004. Gilt selection based on age at first estrus and breeding herd efficiency. Advances in Pork Production 14 (Appendix E)
- Patterson, J.L., G.R. Foxcroft, M. Pettitt and E. Beltranena. 2003. Gilt selection based on age at first estrus and breeding herd efficiency. J. Anim. Sci. 81:199 (Abstract) (Appendix C)
- Patterson, J., M. Pettitt, G.R. Foxcroft and E. Beltranena. 2003. Growth rate and age a first estrus: Impact on managing the gilt pool. Advances in Pork Production 13 (Appendix B)
- Patterson, J., M. Pettitt, G. Foxcroft and E. Betranena. 2002. Growth rate and age at first estrus in relation to efficient gilt pool management. J. Anim. Sci. 80:111. Supplement 1. (Abstract) (Appendix A)

Industry Related Publications

- George Foxcroft and Jennifer Patterson. December 15th, 2003. Better gilt programs can boost sow reproductive efficiency. National Hog Farmer, 2003 Swine Research Review, p15 (Appendix F).
- J. Patterson, M. Pettitt, G. Foxcroft, and E. Beltranena. 2002. Growth rate and age at first estrus: impact on managing the gilt pool. Centred on Swine. Vol. 9, No. 3 (Appendix D)

Seminars and Presentations

- ADSA ASAS PSA Joint Meeting 2004, St. Louis, Missouri, USA - *will be presented by Jennifer Patterson*
- Banff Pork Seminar 2004, Banff, Alberta - *presented by Jennifer Patterson*
- Hypor Technical Meeting, Banff Pork Seminar 2004, Banff, Alberta – *presented by Eduardo Beltranena*
- ADSA ASAS AMPA Joint Meeting 2003, Phoenix, Arizona, USA - *presented by Jennifer Patterson*
- Banff Pork Seminar 2003, Banff, Alberta - *presented by George Foxcroft*
- Banff Pork Seminar 2003, Banff, Alberta - *presented by Jennifer Patterson*

- Pre-Conference Workshop, 2002 – 1st Latin America Swine Production Conference, Foz do Iguazu, Brazil - *presented by George Foxcroft*
- SaskPork Symposium 2002, Saskatoon, Saskatchewan - *presented by George Foxcroft*
- Reproduction Seminar Update 2002, Prairie Swine Centre - *presented by Jennifer Patterson and George Foxcroft*
- American Society of Animal Science Annual Meeting 2002, Quebec City, Quebec - *presented by Jennifer Patterson*
- American Society of Animal Science Midwestern Meeting 2002, Des Moines, IA, USA - *presented by George Foxcroft*

Acknowledgement

Acknowledgement of the ADF and SaskPork's support of this project has been made in any publication or presentation of this work.

Expense Record

For the period July 2001 – March 2004

EXPENSE	FUNDS CONTRIBUTED	ACTUAL
Salaries & Benefits	$60,000.00	$84,116.85
RTU rental, repairs[1]	$15,000.00	$723.50
Materials & Supplies[2]	$11,000.00	$16, 978.54
Project Travel	$4,000.00	$5,203.88
Consultants[3]	$1,000.00	$357.50
Publication Costs[4]	$2000.00	$1,129.05
TOTAL	**$93,000**	**$108,509.32**

[1]Dr. George Foxcroft used funding from the Swine Reproduction and Development Program at the University of Alberta to provide a complete RTU machine and probes valued at $40,000. Therefore these funds were allocated to other expenses related to this project.

[2]Analysis of progesterone, IGF-1 and leptin

[3] We will still be seeking the advice of a statistical consultant in the future.

[4]It is expected that we will be able to submit a paper for publication in April 2004, at this time publication costs will be incurred.

Appendices

APPENDIX A

Subject: Abstract Acceptance for the ADSA/ASAS/CSAS Annual Meeting

Dear Jennifer Patterson:

Congratulations, your abstract has been accepted for presentation at the 2002 Joint Annual ADSA-ASAS-CSAS Meeting to be held July 21-25, 2002 at the Quebec City Convention Center in Quebec City, Quebec, Canada.

Your paper entitled:
Growth rate and age at first estrus in relation to efficient gilt pool Management has been accepted for oral presentation on Tuesday, July 23 at 9:00 AM in room 2000B of the Convention Center. Your paper will appear as abstract 443 in the meeting program as well as in the abstract book. Presenter information and guidelines will be available May 1 and can be found at: http://www.fass.org/quebec02/presenter.asp

Please contact the HQ office (quebec02@assochq.org) immediately if you are unable to present or if you have any other questions. We look forward to seeing you in Quebec.

Dr. James Linn

ABSTRACT #443
Growth rate and age at first estrus in relation to efficient gilt pool management

Jennifer Patterson[1], Murray J. Pettitt[1], George Foxcroft[2] and Eduardo Beltranena[1]
Prairie Swine Centre Inc.[1] University of Alberta[2]

Identifying "select"(cyclic) gilts below market weight and avoiding excessive weights at breeding are two essential features of efficient gilt management systems. Prepubertal Camborough 22 gilts (PIC Canada Ltd; n=152) were used to examine relationships between growth rate and age puberty. Gilts were allocated to the study at 103.7 d of age and 62.2 kg weight, had ad libitum access to feed and water, were housed in groups of twenty and received approximately 20 min direct exposure to a vasectomized boar daily as a pen group for pubertal stimulation starting at 141.1 ± 4.7 d (mean ± SD) of age. Puberty was determined as the first day gilts exhibited the standing reflex in response to contact with a boar; gilts not exhibiting estrus by 180 d of age were considered non pubertal. There was no relationship between growth rate at 100d of age and age at puberty (P=.67, r=.04). As a consequence, inherent differences in age at puberty (Early, 150.4 ± 1.0 d; n=28: Intermediate, 158.4 ± .6 d; n=74: Late, 174.2 ± .9 d; n=33: or non pubertal, n=13) affected (P<.05) weight (109.7 ± 2.3, 115.7 ± 1.4, 126.9 ± 2.1 and 134.0 ± 3.5 kg, respectively) and backfat depth (12.0 ± .8, 14.1 ± .5, 15.2 ± .7 and 15.2 ± 1.0 mm, respectively) but not growth rate (P>.05) (.72 ± .01, .72 ± .01, .73 ± .01 and .76 ± .02 kg/d, respectively) at puberty. Additionally, the Late puberty group averaged 33.1 ± .9 d from stimulation to first estrus. Litter of origin affected age at puberty (P<.04) and is clearly an important contributing factor to inherent differences in the rate of sexual maturity. These results indicate that: 1) with average growth rates exceeding .7kg/d to puberty, gilts would need to cycle by 171 days (31 days after start of stimulation at 140d) to be "selected" below market weight; 22% of gilts failed to meet this target. 2) Later maturing (>175d) and faster growing (>.8 kg/d) gilts weighed >140 kg at first estrus and constitute potentially overweight gilts at breeding and farrowing.

Keywords: Gilts, puberty, growth rate

APPENDIX B

Abstract Accepted for the 2003 Banff Pork Seminar, Banff, Alberta

Growth rate and age at first estrus: impact on managing the gilt pool

J. Patterson[1], M. Pettitt[1], G. Foxcroft[2], and E. Beltranena[1]
Prairie Swine Centre Inc.[1], Swine Research and Technology Centre[2]
e-mail: pattersonj@usask.sask.ca or george.foxcroft@ualberta.ca

Identifying cyclic (select) gilts below market weight and achieving appropriate weights at breeding are two essential features of efficient gilt management systems. The objectives of this study were firstly to characterize the relationships between prepubertal growth rate and age at puberty in response to early boar stimulation, and fertility of "select" gilts over three parties. Secondly, to use this information to develop gilt pool management strategies that 1), minimize non-productive days and financial loss to the producer, and 2), maximize sow lifetime productivity.

Prepubertal Camborough 22 and L42 gilts (N = 509; PIC Canada Ltd) were allocated to the study at 101.3 ± 5.7 d of age and 60.3 ± 8.8 kg (mean ± SD) body weight. The gilts had ad libitum access to feed and water, were housed in groups of twenty and received 20 min direct exposure to an epididimectomized boar daily, starting at 140.0 ± 4.7 d of age. Gilts were deemed to be non-select if pubertal estrus had not been recorded by 180 d of age. Select gilts were bred at third estrus, regardless of age or weight.

Results and Implications

- Approximately 20% og gilts had not cycled by 180 d. Therefore, if early pubertal stimulation is used as a "selection" technique, 120% of breeding requirements should enter the stimulation phase.
- With growth rates exceeding 0.7kg/d from birth to puberty, gilts would need to cycle by 171 days (31 days after start of stimulation at 140d) to be "selected" below market weight. Over 80% of non-select gilts were over market weight at 180 d; culling these gilts would create a financial cost to the breeding unit.
- Weights and ages at puberty ranged from 75.8 - 151.4 kg and 132 - 190 d, respectively, management strategies must be developed to minimize the effect of this variability on breeding weight, entry-to-service non-productive days, and lifetime performance.

Growth rate and age at first estrus: impact on managing the gilt pool

J. Patterson[1], G. Foxcroft[2], M. Pettitt[1], and E. Beltranena[1]

[1]Prairie Swine Centre Inc.
[2]Swine Research and Technology Centre.

Introduction

Identifying "select" (cyclic) gilts below market weight and achieving appropriate weights at first breeding are two essential features of efficient gilt management systems. To attain these two goals, early stimulation with boars to induce first estrus is an important management tool. However, for various reasons, producers delay inducing first estrus (puberty) until 180 to 240 days of age, even though replacement gilts reared under commercial conditions are quite capable of reaching market weight (115 - 120 kg) before 170 days of age. Retention of "non-select" gilts once they have reached market weight results in a financial penalty to the producer. Unnecessary delays in stimulating pubertal estrus and breeding gilts increases feed, barn space and labour costs and may cause welfare problems because of increased physical size of mature sows.

Objectives

The objectives of this study were firstly, to characterize the relationships between prepubertal growth rate and age at puberty in response to early boar stimulation, and fertility of "select" gilts over three parities. Secondly, to use this information to develop gilt pool management strategies that 1) minimize non-productive days and financial loss to the producer, and 2) maximize sow lifetime productivity.

Materials and Methods

Prepubertal Camborough 22 and L42 gilts (N = 509; PIC Canada Ltd) were allocated to the study at 101.3 ± 5.7 d of age and 60.3 ± 8.8 kg (mean ± SD) body weight. The gilts had ad libitum access to feed and water, were housed in groups of twenty and received 20 min direct exposure to an epididimectomized boar daily, starting at 140.0 ± 4.7 d of age. Gilts were deemed to be "non-select" if pubertal estrus had not been observed by 180 d of age. "Select" gilts were bred at third estrus, regardless of age or weight.

Results

Our results confirm that at commercially acceptable growth rates (0.55 – 0.80 kg/d) there is no relationship between growth rate (birth to 100 days of age) and age at puberty (r=0.079; P>0.15). As a consequence, inherent differences in age at puberty (Early, Intermediate, Late, Non-responders) affected days from first stimulation to first estrus or designation as non-select, and weight, backfat depth and growth rate at puberty (Table 1).

Table 1. Characteristics measured at the onset of puberty

	Early	Intermediate	Late	Non-responders[1]	SEM	*Group* P-value[2]	*Sow* P-value[3]
n	104	161	114	112	–	–	–
Pubertal Age[4]	148.9[a]	159.7[b]	175.3[c]	*(>180)*	0.81	0.0001	0.0289
Days to Puberty	8.5[a]	19.6[b]	35.2[c]	*(>40)*	0.82	0.0001	0.0364
Weight	106.1[a]	118.0[b]	128.3[c]	131.3[c]	2.0	0.0001	0.0001
Backfat depth	12.7	13.7	13.7	13.5	0.45	0.2366	0.0001
Growth Rate	0.688[a]	0.718[b]	0.722[b]	0.729[b]	0.009	0.0014	0.0001

[1] Average age of non-responders was 179.7 days at the time of removal from the experiment.
[2] Puberty is defined as the first day a gilt exhibits the standing reflex in the presence of a boar.
[3] Group defined as the difference between early, intermediate, late and non-responders.
[4] Sow defined as the differences between dam at birth.

Practical Implications

Q - What is the consequence of high growth rates (>0.7kg/d from birth to puberty) on culling of non-select gilts?

A - As illustrated in Figure 1, nearly 80% of non-select gilts were over market weight (120 kg) at 180 d, ***culling these gilts (>120 kg) could create a financial cost to the breeding unit.***

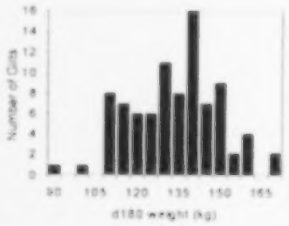


Figure 1. The weight of non-responders at 180d of age (n=88)

Q - With early stimulation of gilts, what proportion of gilts can one expect to cycle within 40d and how can this be useful in my herd?

A- The distribution of gilts reaching puberty is illustrated in Figure 2. 77% of gilts had cycled by 180 d. 23% did not.

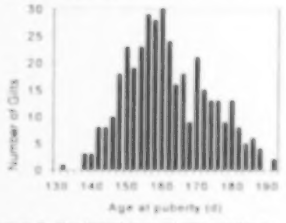


Figure 2. The distribution of gilts reaching puberty

Therefore, if early pubertal stimulation is used as a "selection" technique, ***at least 120% of breeding requirements*** should enter the stimulation phase.

Q - What are the consequences of large ranges in weight and age at puberty and breeding on sow performance?

A - Ages and weights at puberty ranged from 132 to 190 d and 75.8 to 151.4 kg, respectively. ***Management strategies must be developed to minimize the effect of this variability on breeding weight (Figure 3), entry-to-service non-productive days, and lifetime performance.***

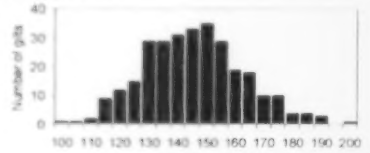


Figure 3. The distribution of weights at breeding

Q - What are the consequences of varying ages and weights at puberty on sow lifetime performance?

A - We are currently in the process of collecting the lifetime performance data over three parities; preliminary results are illustrated in Table 2.

Table 2. Preliminary performance data

	Early	Intermediate	Late	SEM	P-value
Breed Weight (kg)	131.8[a] (n=80)	144.7[b] (n=128)	152.9[c] (n=87)	1.7	0.0001
Breed Backfat (mm)	14.2[a] (n=81)	15.8[b] (n=130)	15.0[ab] (n=87)	0.48	0.0399
Farrow Weight (kg)	178.2[a] (n=53)	190.8[b] (n=80)	199.4[c] (n=38)	2.7	0.0001
Farrow Backfat (mm)	14.4 (n=53)	15.7 (n=80)	15.4 (n=39)	0.63	0.3068
Total born alive	10.8 (n=32)	10.4 (n=61)	10.3 (n=32)	0.54	0.7520
Total born dead	0.57[a] (n=33)	0.84[a] (n=61)	1.55[b] (n=31)	0.24	0.0136
Wean Weight (kg)	164.3[a] (n=43)	177.0[b] (n=62)	184.2[b] (n=31)	5.0	0.0073

Acknowledgements - Strategic program funding provided by SaskPork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Development Fund (ADF). Direct funding from SaskPork, ADF, Alberta Pork and AARI for this project.

APPENDIX C

Subject: 2003 ASAS ADSA AMPA Meeting - Accepted Poster Presentation

Dear Dr. Patterson,

Thank you for submitting your abstract to the American Dairy Science Association (ADSA), American Society of Animal Science (ASAS), and Mexican Association of Animal Production (AMPA) Joint Meeting. We are pleased to inform you that this abstract has been accepted as a poster presentation and will appear in the section noted.

2003 ADSA-ASAS-AMPA Joint Meeting
Tracking no.: 1000349
Section: Swine Species
Presentation Date: Monday June 23
Presentation Time: 7:30 am - 9:30 am
Presentation Date: Wednesday June 25
Presentation Time: 7:30 am - 9:30 am

Once the program is finalized, you can confirm the assigned abstract number, location and time of your presentation. The program will be posted online at www.fass.org/phoenix03. The meeting is June 22-26, 2003 at the Phoenix Civic Plaza in Phoenix, Arizona.

GILT SELECTION BASED ON AGE AT FIRST ESTRUS AND BREEDING HERD EFFICIENCY.

J.L. Patterson[1], G.R. Foxcroft[2], M.J. Pettitt[1], and E. Beltranena[1],
Prairie Swine Centre Inc., Saskatoon, SK[1], and Swine Research & Technology Centre, University of Alberta, Edmonton, AB[2].

The impact of gilt selection based on age at first estrus on breeding herd performance was determined in 509 C22 and L42 (PIC Canada) gilts given direct daily contact with vasectomized boars from 140.1 ± 5.1 d of age and classified with respect to age at first estrus (Early: EP, 148.0 ± 0.5; Intermediate: IP, 159.8 ± 0.4; Late: LP, 175.7 ± 0.5 d; or Non-Responsive by 180 d: NR; P<0.05). For gilts in estrus by 180 d, breeding at third estrus resulted in differences in body weight at breeding (EP: 130 ± 2; IP: 143 ± 2; and LP: 153 ± 2 kg; P<0.01). Breeding rate (percentage of gilts on inventory eventually bred) was lowest for NR gilts (EP: 96.2; IP: 91.3; LP: 90.3; and NR: 72.3 %; P<0.01). Age at first estrus did not affect farrowing rate of gilts bred (EP: 92.0; IP: 93.6; LP: 92.1; and NR: 86.2 %; P>0.05) or pigs born alive (EP: 10.0 ± 0.4; IP: 10.5 ± 0.3; LP: 10.3 ± 0.4; and NR: 9.7 ± 0.5; P>0.05), but did affect pigs born dead (EP: 0.48 ± 0.17; IP: 0.45 ± 0.14; LP: 1.10 ± 0.17; and NR: 0.46 ± 0.21; P=0.01). Preliminary data from weaned, parity 1 sows indicate no significant effects on weaning-to-estrus interval (EP: 5.2 ± 0.6; IP: 6.0 ± 0.5; LP: 4.9 ± 0.6; and NR: 7.1 ± 0.8 d; P>0.05) or percent sows rebred after weaning (EP: 91.7; IP: 80.6; LP: 83.6; and NR: 80.0 %; P>0.05). However, estimates of cumulative non-productive days (NPD) per gilt originally on inventory, inclusive of NPD due to gilts and sows culled by d 18 after weaning, were EP, 37; IP, 60; LP, 80 and NP, 80 d. Corresponding estimates of NPD per pig born in the first litter were EP, 4.3; IP, 6.8; LP, 9.7 and NP, 13.0 d. These data indicate important differences in production efficiency related to selection on age at first estrus. Considered together with increased costs of higher replacement rates, costs of time spent on unproductive heat checks and increased breeding costs per pig born, our data suggest substantial savings can be realized by identifying late-cyclic and non-cyclic gilts at an early age.

Keywords: Gilts, Puberty, Productivity

GILT SELECTION BASED ON AGE AT FIRST ESTRUS AND BREEDING HERD EFFIENCY

J.L. Patterson[1,2], G.R. Foxcroft[2], M.J. Pettitt[1], and E. Beltranena[1]

[1]Prairie Swine Centre, Inc., Saskatoon, SK, S7H 5N9

[2]Swine Reproduction-Development Program, Dept. AFNS, University of Alberta, Edmonton, AB, T6G 2P5; *Email:*

INTRODUCTION

Three essential features of efficient gilt management systems are:

1. **Identifying "select" (cyclic) gilts below market weight.** Retention of "non-select" gilts once they have reached market weight results in a financial penalty to the producer.
2. **Achieving appropriate weights at first breeding to sustain maximum lifetime performance.** A minimum body weight at farrowing of 175 kg may be necessary to protect against excessive loss of protein mass in first lactation (Clowes et al., 2001).
3. **Minimizing accumulated non-productive days (NPD) in the gilt pool.** Unnecessary delays in stimulating pubertal estrus, breeding gilts & efficient allocation of gilts to breeding groups are the largest contributors of NPD's in the herd.

EXPERIMENTAL PROCEDURES

Prepubertal Camborough 22 and L42 gilts (N = 509, PIC Canada Ltd) were allocated to the study at 101.3 ± 5.7 d of age and 60.3 ± 8.8 kg (mean ± SD) body weight. The gilts had ad libitum access to feed and water, were housed in groups of twenty and received 20 min direct exposure to an epididimectomized boar daily, starting at 140.0 ± 4.7 d of age. Gilts attaining puberty by 180d of age were deemed to be "select" gilts and classified as: Early (EP), Intermediate (IP) and Late (LP) with respect to age at first estrus. Gilts were deemed to be "Non-select" (NP) if first estrus was not shown by 180 d of age. Table 1 summarizes pubertal data previously presented.

Table 1. Characteristics measured at the onset of puberty

	EP	IP	LP	NP	SEM	*P*-Value
n	104	161	114	112	-	-
Pubertal Age (d)	148.5[a]	159.7[b]	175.3[c]	*(>180)*	0.8	0.0289
Weight (kg)	106.1[a]	118.0[b]	128.3[c]	131.3[c]	2.0	0.0001

"Select" gilts were bred at third estrus, regardless of age or weight. "Non-select" gilts were added to the gilt pool by production staff using available techniques (i.e. treatment with PG 600). To determine sow lifetime performance, data on sow body weight, loin and backfat depth at farrowing and weaning; total litter size born alive, dead and mummies; weaning to estrus interval and reason for culling are being collected over three parities.

RESULTS

As a percentage of the total number of gilts available in each group, fewer "Non-Select" gilts were bred than any of the classes of "Select" gilts. Consequently, pregnancy rate, farrowing rate, weaning rate and the percent rebred after weaning after first parity for NP gilts were lower than EP, IP or LP gilts.

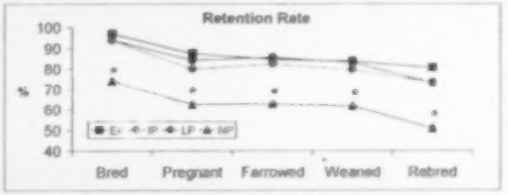


Figure 1. Breeding, pregnancy, farrowing, weaning and rebreeding rate of parity 1 sows as a percentage of gilts originally on inventory. *significant differences between 'Non-select' (NP) gilts and 'Select' (EP, IP, LP) gilts.

Considering only weaned parity 1 sows, class of gilt affected ($P < 0.02$) the percentage of animals pregnant as parity 2 sows (EP: 94.2; IP: 87.2; LP: 91.0; and NP: 76.6 %).

Breeding herd efficiencies (NPD/gilt born) declined as age at puberty increased, when gilts were bred at 3rd estrus irrespective of weight or age (Table 2). Had gilts been bred according to weight, irrespective of age, breeding herd efficiencies would not have been different for EP, IP and LP gilts. However, retention of NP gilts in the breeding herd would still have resulted in unnecessary accumulation of NPD.

Table 2. Breeding herd efficiency as determined by NPD accumulated by d30 of gestation of parity 2.

	EP	IP	LP	NP	SEM	*P*-Value
NPD actual[1,2]	50.5[a]	58.5[ab]	75.5[b]	71.1[ab]	4.6	0.0002
NPD predicted[3]	*41.2*[a]	*41.4*[a]	*49.2*[b]	*69.2*[c]	*4.7*	*0.0001*
Born Alive	10.1	10.1	10.3	10.2	0.3	0.3583
Born alive adjusted[4]	8.5	8.6	8.5	6.2	-	-
NPD/pig born[5]	5.9	6.8	8.9	11.4	-	-
NPD/pig born[6]	*4.8*	*4.8*	*4.8*	*11.2*	-	-

[1]NPD calculated from 170 d (days to reach slaughter weight of 120kg with an average growth rate 0.71kg/d).

[2]*Acutal # NPD accumulated to d30 of gestation of parity 2.*

[3]*Predicted # NPD if gilts bred at 135 kg body weight OR 3rd estrus.*

[4](Total gilts available X farrowing rate X actual born alive)/total number of gilts available

[5]NPD actual/ born alive adjusted

[6]*NPD predicted/ born alive adjusted*

In the total population of gilts, large ranges in predicted NPD existed (Figure 2). The extreme values in NPD's can be attributed to multiple re-breedings as gilts and failure to detect open gilts, irrespective of age at puberty.

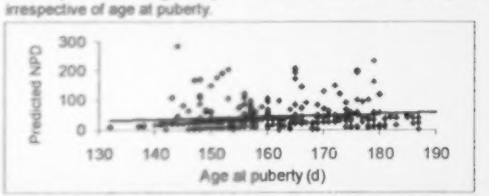


Figure 2. Relationship between age at puberty and predicted NPD. (NPD=0.46x – 31.1, $R^2 = 0.02$, $P = 0.02$)

Figure 3 illustrates the weight of EP, IP and LP gilts over three parities. Increased weight of LP gilts increases feed, barn space and labour costs and may cause welfare problems because of increased physical size of mature sows.

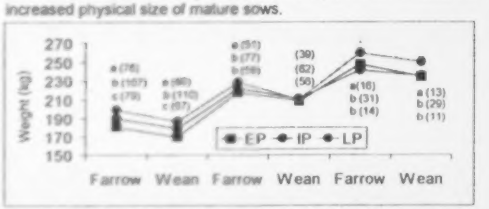


Figure 3. Preliminary results of body weight at farrowing and weaning over three parities. a,b,c Means in same time period without common superscript letters differ ($P < 0.01$). Number in parenthesis (n).

IMPLICATIONS

These data indicate important differences in production efficiency related to selection on age at first estrus. Considered together with increased costs of higher replacement rates, costs of time spent on unproductive heat checks and increased breeding costs per pig born, our data suggest substantial savings can be realized by identifying late-cyclic and non-cyclic gilts at an early age.

ACKNOWLEDGEMENTS

Strategic program funding provided by SaskPork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Development Fund (ADF). Direct funding from SaskPork, ADF, Alberta Pork and AARI for this project.

APPENDIX D

Centred on Swine, Vol. 9, No. 3

Growth rate and age at first estrus: impact on managing the gilt pool.

Jennifer Patterson[1], Murray Pettitt[1], George Foxcroft[2] and Eduardo Beltranena[1], Prairie Swine Centre Inc.[1], Swine Research and Technology Centre[2]

Identifying "select"(cyclic) gilts below market weight and achieving appropriate weights at first breeding are two essential features of efficient gilt management systems. To attain these two goals, early stimulation with boars to induce first estrus is an important management tool. However, for various reasons, producers delay inducing first estrus (puberty) until 180 to 240 days of age, even though replacement gilts reared under commercial conditions are quite capable of reaching market weight (115 - 120 kg) before 170 days of age. Retention of non-select gilts once they have reached market weight results in a financial penalty to the producer. Unnecessary delays in stimulating pubertal estrus and breeding gilts increases feed, barn space and labour costs and may cause welfare problems because of increased physical size of mature sows.

Therefore, the objective of this ongoing study is 1) to characterize the relationships between prepubertal growth rate and age at puberty in response to early boar stimulation, and fertility over three parties 2) to minimize non-productive days and financial loss to the producer and 3) to maximize sow lifetime productivity as gilts enter the breeding herd.

To address these objectives, an experiment involving approximately 500 prepubertal Camborough 22 and L42 gilts (PIC Canada Ltd) at approximately 100 days of age and 60 kg weight, is being conducted at PSC Floral Research Farm. All gilts have ad libitum access to feed and water, and are housed in pens of twenty. For pubertal stimulation, gilts receive approximately 20 minutes direct exposure to a mature epididimectomized boar daily, as a pen group, starting at 140 d of age. Gilts not exhibiting estrus by 180 days of age are considered non-pubertal.

Figure 1 illustrates the overall distribution of the age of the gilts that have reached puberty so far. Overall, out of 385 gilts, 63% of all gilts reached puberty within 30 days of simulation, 79% of gilts were pubertal within 40 days of stimulation and 21% of gilts were considered non-pubertal at 40 days of stimulation (Figure 1). Therefore, based on the results collected so far, we estimate that if early pubertal stimulation is used as a "selection" technique, 120% of breeding gilt requirements should enter the stimulation phase (expecting 20% not to cycle) to obtain the required number of gilts cycling within 40d.

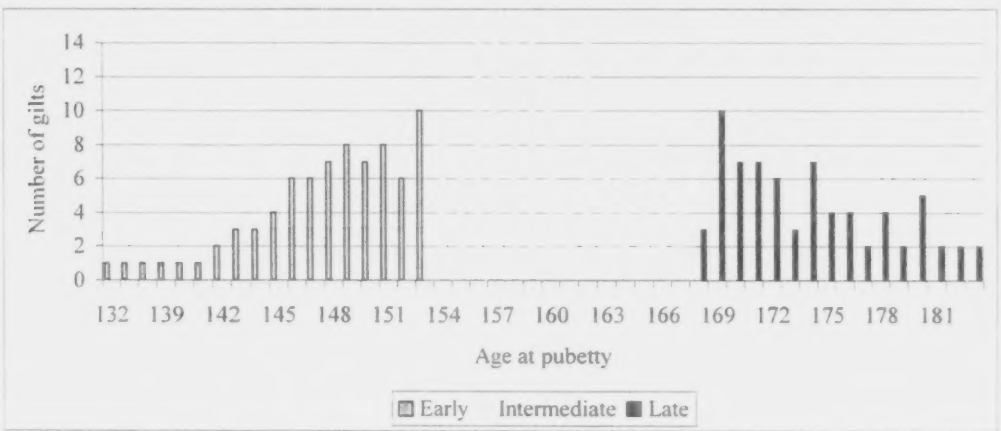


Figure 1. Distribution of gilts attaining puberty in response to direct contact with a boar

Our results confirm that at commercially acceptable growth rates (0.55 – 0.80 kg/d) there is no relationship between growth rate (birth to 100 days of age) and age at puberty. As a consequence, inherent differences in age at puberty (Early, Intermediate, Late, Non-responders) affected days from first stimulation to first estrus or designation as non-select, and weight, backfat depth and growth rate at puberty (Table 1).

Table 1.

	Early	Intermediate	Late	Non-responders †
n	78	148	81	80
Pubertal Age *	148.2	159.6	175.1	-
Days from start of boar stimulation to Puberty	7.9	19.3	34.8	-
Weight at puberty	104.2	116.0	126.4	130.8
Backfat Depth at puberty	12.7	13.8	13.3	14.0
Growth Rate (birth to puberty)	0.689	0.709	0.715	0.731

† Average age of non-responders was 179.7 days at the time of removal from the experiment.
* Puberty is defined as the first day a gilt exhibits the standing reflex in the presence of a boar

An important point that producers should consider is the weight of the gilts considered non-responders at 180 days of age. Overall, 21% of all gilts were considered non pubertal and 82% of these were above market weight (120 kg), thus resulting in a financial penalty to the producer if these gilts were to be removed as market animals.

Implications

These preliminary results indicate that:

1) if early pubertal stimulation is used as a "selection" technique, 120% of breeding requirements should enter the stimulation phase (expecting 20% not to cycle) to obtain the required number of gilts cycling within 40d,
2) with growth rates exceeding 0.7kg/d from birth to puberty, gilts would need to cycle by 171 days (31 days after start of stimulation at 140d) to be "selected" below market weight. 37% of all gilts failed to achieve this, and could potentially represent financial cost to the breeding unit
3) with weights and ages at puberty ranging from 75.8 - 151.4 kg and 132 - 190 d, respectively, management strategies must be developed to minimise the effect of this variability on lifetime performance.

We are now in the process of collecting data with respect to lifetime productivity.

We would like to gratefully acknowledge the financial support of SaskPork and the Saskatchewan Agriculture and Food, Agriculture Development Fund for this project.

APPENDIX E

2003 Swine Research Review

National Hog Farmer, Dec 15, 2003

Better Gilt Programs Can Boost Sow Reproductive Efficiency

Improving gilt management programs will result in reduced sow replacement rates, improved sow fitness, increased labor efficiency and better space utilization.

To achieve that success, reduce annual replacement rates while still meeting breeding targets. Annual replacement rates on swine operations average 62.9% in the U.S. and 58.7% in Canada, according to PigCHAMP data.

Recent research points to three key elements in good gilt management programs:

- Implementing a strict selection program that identifies the most fertile animals;
- Achieving appropriate weights at first breeding to prolong lifetime sow performance; and
- Minimizing non-productive days (NPD) in the gilt pool.

A selection program must identify the 75-80% of pre-pubertal gilts that best respond to boar stimuli.

Based on earlier research at the Swine Research and Technology Centre, and a current study at Prairie Swine Centre, Saskatoon, the link between age at boar-induced puberty and lifetime performance is being examined in Camborough 22 and L42 gilts. Gilts are exposed to vasectomized boars for 20 minutes daily starting at 140 days of age. Gilts achieving puberty by 180 days of age are named " select" gilts and classified as Early (EP), Intermediate (IP) or Late (LP) for first standing estrus. EP gilts have a recorded heat within 140 to 155 days, IP gilts within 155 to 170 days and LP gilts within 170 to 180 days. Gilts are classified " non-select" (NP) if puberty is not reached by 180 days of age.

" Select" gilts are bred at third estrus regardless of age or weight. To meet breeding targets, most NP gilts are bred with the aid of PG600.

These breeding results have shown that pregnancy rate, farrowing rate, weaning rate and the percent of gilts rebred after weaning the first litter were lower for NP gilts than for EP, IP or LP gilts (Figure 1, on page 15).
First-litter sows need to weigh 385-396 lb. to protect them from adverse affects of first lactation on subsequent

fertility, according to recent research.

This data also suggests that instead of following the conventional wisdom of using age to determine time of breeding, ad libitum-fed gilts should be bred based on weight (297-330 lb.). If gilts are also " select" (recorded standing heat within a set number of days of direct contact with mature boars), and an upper limit of third estrus for breeding is also required, the number of non-productive days (NPD) will dramatically drop (Table 1).

If one NPD is worth $2/day, University of Alberta data says efficient gilt management strategies on a 600-sow unit will produce savings of $11,426 due to reduced NPDs (Table 1).

Table 1. Breeding Herd Efficiency Measured as Cumulative Non-Productive Days to Day 30 of Gestation in Parity 2*

	Early Puberty	Intermediate Puberty	Late Puberty	Non-Select (No Estrus)
NPD Actual[1,2]	50.5	58.5	75.5	71.1
NPD Predicted[3]	41.2	41.4	49.2	69.2
Reduction in NPD	9.3	17.1	26.5	-----
Expected Savings[4]	$18.60	$34.20	$53.00	-----

*Inclusive in estimated non-productive days (NPD) for each gilt category are days-to-service as gilts, wean-to-service interval, days to culling for gilts not bred or not farrowing, and non-productive days (NPD) for sows culled after weaning their first litter (Prairie Swine Centre and University of Alberta, Swine Research and Technology Centre, unpublished data, 2003).

[1]NPD calculated from 170 days (days to reach slaughter weight of 264 lb. with an average growth rate of 1.6 lb./day).

[2]Actual number of NPDs accumulated to Day 30 of gestation of parity 2.

[3]Predicted number of NPDs if gilts bred at 297 lb. body weight or third estrus.

[4]Example of a 600-sow unit × 45% replacement = 270 gilts × 120% to meet requirements = 324 gilts × (average of $18.60 + $34.20 + $53.00 = $11,426 (savings/year)).

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APPENDIX F

Gilt management for improved production

J. Patterson[1,2], G. Foxcroft[2], M. Pettitt[1] and E. Beltranena[1,3]
Prairie Swine Centre Inc.[1], Swine Research and Technology Centre[2], Alberta Agriculture Food and Rural Development[3] *e-mail:* george.foxcroft@ualberta.ca

PigChamp 2002 data shows that on Canadian swine operations the average herd female inventory is 1046 with an average replacement rate of 58.7%, (http://www.pigchamp.com/benchmarking.asp). From these data, it is evident that an excessively large pool of cycling gilts is required to meet these replacement requirements. Therefore, it is essential that a producer adopt a gilt management program that will meet replacement targets from a smaller pool of gilts with improved lifetime breeding potential.

An on-going study is examining the relationship between age at puberty and lifetime performance in Camborough 22 and L42 gilts. Gilts received 20 min direct exposure to an epididimectomized boar daily, starting at 140.0 d of age. Gilts attaining puberty by 180d of age were deemed to be "select" gilts and classified as Early (EP), Intermediate (IP) and Late (LP) with respect to age at first estrus. Gilts were deemed to be "Non-select" (NP) if first estrus was not shown by 180 d of age.

As a percentage of the total number of gilts on inventory at the start of stimulation in each group, fewer "Non-Select" gilts were bred than any of the classes of "Select" gilts. Consequently for NP gilts, pregnancy rate, farrowing rate, weaning rate and the percent rebred after weaning after first parity (expressed as a % of gilts originally on inventory) were lower than for EP, IP or LP gilts. Considering only those gilts successfully weaned as parity 1 sows, class of gilt affected ($P < 0.02$) the percentage of animals pregnant as parity 2 sows (EP: 94.2; IP: 87.2; LP: 91.0; and NP: 76.6 %). Furthermore, EP and IP gilts accumulated fewer non-productive days (NPD) until rebreeding at parity 1 than either LP or NP gilts (EP: 50.5; IP: 58.5; LP: 75.5; and NP: 71.1).

Implications:

In summary, it is predicted that if a producer were to implement an efficient gilt management program on farm, it would ultimately result in improved production through reduced sow replacement rates, improved sow fitness, decreased sow death losses, increased labour efficiency and space utilization.

APPENDIX G

Abstract Accepted for the 2004 FASS Meeting in St.Louis, Missouri

Hello,

We are pleased to inform you that abstract (#4944) has been accepted.

Information regarding your presentation time and format will be sent to you at a later date.

We are excited to announce that based on requests and comments from ADSA/ASAS/PSA members, computers will be provided in the presentation rooms! All electronic presentations will be preloaded prior to the meeting. More detailed information will be provided later.

Thank you
Tom Rathje

Gilt selection for improved lifetime productivity.

J.L. Patterson[1], G.R. Foxcroft[1], M.J. Pettitt[2], and E. Beltranena[1], Swine Research & Technology Centre, University of Alberta, Edmonton, AB[1]; Prairie Swine Centre Inc., Saskatoon, SK[2]

In a study of 509 pre-pubertal C22 and L42 (PIC Canada) gilts given direct daily boar contact from 140.1 ± 5.1 d of age, and classified with respect to age at first estrus as Early (148.0 ± 0.5 d), Intermediate (159.8 ± 0.4 d) or Late (175.7 ± 0.5 d) responders, or as Non-Responsive (NR; not cyclic by 180 d), earlier responding gilts accumulated less non-productive days (NPD) in the gilt pool (J. Anim. Sci. Vol 81, Suppl 1). Data on reproductive performance of these gilts until either culling or farrowing as third parity sows is now available to evaluate longer-term productivity. The main differences detected were between any gilt recorded as initially responding to boar contact (R) compared to NR gilts. Analyzed on the basis of overall performance of gilts originally on inventory, R were more productive than NR gilts ($P<0.01$), as measured by the percentage of gilts successfully bred (R = 96.2 vs. NR = 75.2 %), farrowing one (R = 85.0 vs. NR = 64.2 %), two (R = 72.2 vs. NR = 49.5 %), or three litters (R = 57.6 vs. NR = 37.0 %), and as the average litters produced per gilt on inventory (R = 2.5 ± 0.1 vs. NR = 1.7 ± 0.1 litters), reflecting a lower retention rate of NR gilts in the breeding herd. When different gilt categories were compared on the basis of productivity of sows that actually produced litters, sow NPD were higher ($P < 0.05$) in NR compared to R females, as measured by average weaning-to-estrus interval (6.4 ± 0.4 vs. 5.6 ± 0.2 d, respectively) and weaning-to-conception interval (11.2 ± 1.3 vs. 7.5 ± 0.6 d, respectively). In contrast, mean total pigs born per litter at first, second and third parity was not different ($P > 0.05$) between R(10.7 ± 0.4, 11.2 ± 0.4 and 12.5 ± 0.5) and NR (10.9 ± 0.2, 11.3 ± 0.2 and 12.1 ± 0.2) gilts. Gilt selection based on recorded first estrous during periods of good boar contact (heat-no-serve) is therefore predictive of better lifetime reproductive performance.

Gilts
Selection
Lifetime Productivity